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INVESTIGATION OF THERMAL STABILITY OF THE MICROSURFACE OF ASTRONOMICAL MIRRORS MADE OF ALLOY AMg6L WITH CHROMIUM AND NICKEL COATINGS

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Soobshch. Byurakanskoy Observatorii
Vypusk 38, str. 66 - 71,'
Izd-vo V. A. Ambartsumyana
Akademii Nauk Armyanskoy SSR, 1967.

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SUMMARY

An investigation was made of the effect of temperature variations and of the difference in the linear expansion coefficient of alloy AMgL6, of electrolytic chromium and of chemical nickel on the quality of microsurfaces of mirrors. These mirrors were made of AMgL6 alloy with chromium and nickel coatings of various thicknesses. The experiment was carried out at temperatures of -95°, $+20^{\circ}$, $+60^{\circ}$ and $+100^{\circ}$C.

It was shown that mirrors coated with 10 to 50μ of chromium did not alter their microsurface quality. In the cases of coatings thicker than 50μ , cracks appeared on the mirror surface. Temperature variations have no effect on the quality of nickel coatings. The origin of the cracks can be explained by great internal strains in the chromium coatings. The greater the difference between the coefficient α of the coating substances and the mirror itself, the greater the inner strains that originate in the coating.

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In order to determine the effects of high and low temperatures, of the differences in the expansion coefficients of aluminum alloy, electrolytic chromium and chemical nickel on the quality of mirrors' microsurface, we conducted a series of tests on polished mirrors made of alloy AMg6L with chromium and nickel coatings. These tests were conducted at temperatures of -95°, $+20^{\circ}$, $+60^{\circ}$ and $+100^{\circ}$C. Increased temperature ($+60^{\circ}$ and $+100^{\circ}$C) was obtained in the laboratory-type III-005 thermostat. The prescribed temperature was automatically obtained with the aid of a TK-6 contact thermometer achieving a precision to $\pm 1^{\circ}$. The low temperature tests of samples were conducted in a hermetically sealed box with solid carbon dioxide (dry ice). The samples were disposed between carbon dioxide slugs. The temperature was measured by means of a thermometer with measurement range from $+20^{\circ}$ to $+100^{\circ}$C. At the latter tem-

(*) ISSLEDOVANIYE NA TERMOSTOYKOST' MIKROPOVERKHNOSTI ASTRONOMICHESKIKH ZERKAL, IZGOTOVLENNYKH IZ SPLAVA AMg6L S KHROMOVYM I NIKELEVYM POKRYTIYEMI perature the time lag was of 6 hours, at 60°C it was of 8 hours and at -95° - 20 hours. The heating of parts in thermostat to the required temperature took place gradually, starting from room temperature. The cooling to room temperature also was gradual.

Compiled in Table 1 are the greatest and the smallest thicknesses of tested samples' coating, immediately after application: a, and also after polishing and finish: b .

TABLE 1

THICKNESS OF COATINGS IN MICRONS

COATING	No. of Samples 1	2	3	4	5
CHROMIUM					
a	47 - 40	55 - 45	85 - 100	100 - 120	220 - 240
b	10 - 15	30 - 20	30 - 50	50 - 80	120 - 140
NICKEL					
a	30 - 35	40 - 45	50 - 70	65 - 75	—
b	10 - 15	15 - 20	35 - 40	40 - 50	—

The quality of the microsurface was checked by visual means and also by photographing on the universal microscope "NEOPHOT" by Zeiss with a 200 x magnification prior and after tests.

The results of the tests for chromium coatings, completed in the chrome plating regime, are compiled in Table 2.

The results of these experiments show that for the indicated cycle of thermal tests the microsurface of mirrors with chromium coatings from 10 to 50 μ remained unchanged. For chromium coatin thickness from 50 to 120μ cracks have formed on mirror surface after heating. Consequently, there exists a threshold thickness thickness of chromium layer over AMg6L alloy, applicable as the operational reflecting surface of the astronomical mirror. Microcracks appear on the surface of the mirror when this threshold is exceeded. The formation of microcracks on the chromium coating can be explained as follows. As is well known, inner strains appear in the electrolytic chromium layer, attaining high values (3700 - 6000 kg/cm^2) and depending upon the nature of of coating, the method of its application and the state of the packing block. In the case in question the coating regimes, the nature and the state of the packing block are identical in all thicknesses. In chromium layers of thickness from 100 to 120μ no microcracks were observed immediately after coating, but above that, say at 220 μ, webs of cracks were noticeable. These cracks were formed in the electrolysis process on account of the excess of inner strain of chromium layer's breaking point.

TABLE 2

TEMPERATURE	Number of the Samples				
	1	2	3	4	5
+20°C	Clean surface without cracks	Clean surface without cracks	Clean surface without cracks	Clean surface without cracks	Surface covered by a web of cracks
+60°C	"	"	"	Cracks appeared	No noticeable new cracks
+100°C	"	"	Cracks appeared	No noticeable new cracks	New cracks have appeared
-95°C	"	"	No noticeable new cracks	No noticeable new cracks	No noticeable new cracks

ANNOTATION. Coating thicknesses are indicated in Table 1.

The magnitude of the residual internal stress of chromium layer is influenced by the concomitant existence of temperature variation and difference in the coefficients of linear expansion z of adhering materials. The more significant the difference in the values of coefficient z, the greater the internal stresses occurring at temperature variation. Just how great is the difference in the values of the linear expansion coefficient of electrolytic chromium and AMg6L alloy is well known: for the electrolytic chromium $\alpha = 6.25 \cdot 10^{-6}$ 1 deg, and for AMg6L alloy $\alpha = 23.8 \cdot 10^{-6}$ 1 deg.

It follows from the results of the experiment that in order to obtain on mirrors a microsurface of good quality, when these mirrors are made of aluminum-magnesium alloy with chromium coating, a thickness of chromium coating greater than 85 to 100μ is inadmissible.

The results of tests show that for small thicknesses of chromium coatings (to 50 μ) the value of the internal stress does not exceed the breaking strength of chromium layer and this is why no destruction of the coating is observed. But, as the thickness of the coating increases (50μ and above) the temperature gradient induces inside the coating stresses exceeding the breaking strength of electrolytic chromium, which leads, in the final count, to the appearance of a web of microcracks over the surface of the coating.

The microsurface of chemical nickel coating over an alumino-magnesium base did not vary either for extreme coating thicknesses of 65 to 75μ (40 to 50 μ after treatment), or for thinnest coatings of 30 to 35 μ (i.e. 10 to 15μ after treatment), as temperature fluctuated within the limits from +100°C to -95°C. Consequently, the obtaining of a quality microsurface on nickel coating applied chemically, is possible for the given temperature range (-90 to +100°) and thickness (up to 65 - 75 μ).

In conclusion it should be stressed that the thermal tests of the investigated samples were conducted by us with the cooperation of senior engineer G. G. Lavrent'yeva.

**** THE END ****

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